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DEVELOPMENT AND ANALYSIS OF A MODULAR APPROACH TO PAYLOAD SPECIALIST TRAINING

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16. ABSTRACT

Traditionally space flight crew training has been very detailed, tedious, and expensive. With the advent of the Shuttle era this may no longer be feasible. A training program must meet temporal, spatial, and economical restraints while retaining maximum flexibility. A modular approach is defined and analyzed to determine its feasibility of meeting these requirements. It is shown that single high fidelity trainers are not required, but certain equipment can be configured as trainers for many different experiments and training may be simultaneously conducted on individual experiments using these experiment modular trainers. A detailed training analysis procedure is described together with a parametric approach to interpreting these data in relation to training facility requirements.

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LIST OF ACRONYMS

CCTV	Closed Circuit Television
CDMS	Command and Data Management System
CPSE	Common Payload Support Equipment
CRT	Cathode Ray Tube
CVT	Concept Verification Test
DOD	Department of Defense
ESA	European Space Agency
EVA	Extra-Vehicular Activity
IMAP	Integrated Mission Analysis and Planning
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
ORA	Operations Requirement Analysis
PA	Public Address
POC	Payload Operations Center
PSS	Payload Specialist Station
RAU	Remote Acquisition Unit
SimCom	Simulation Computer
TBD	To Be Determined

TECHNICAL MEMORANDUM X-64980

DEVELOPMENT AND ANALYSIS OF A MODULAR APPROACH TO PAYLOAD SPECIALIST TRAINING

1.0 SUMMARY

A description of the development and analysis of a modular approach to Spacelab payload crew training is presented in this report. Representative missions are defined for training requirements analysis, training hardware, and simulations. Training times are projected for each experiment of each representative flight. A parametric analysis of the various flights defines resource requirements for a modular training facility at different flight frequencies. The modular approach is believed to be more flexible, time saving, and economical than previous single high fidelity trainer concepts.

2.0 INTRODUCTION

The American Space Program has been characterized by highly successful missions, due in part to the lengthy, extensive training programs provided for the astronauts. Widely spaced launch schedules, a dedicated cadre of astronauts, a generous budget, and a limited number of total flights enabled such extensive training to be provided. Now, however, NASA is entering the Shuttle era where the latest mission model identifies as many as 60 flights per year, with the total number of flights planned being over 500. To support such a number of flights, a more cost conscious budget will be a necessity.

To operate the Shuttle a professional cadre of astronauts will still be needed as pilots and crew members. However, since Spacelabs will be flown on many of these Shuttle flights, additional crewmen will be required. On Spacelab flights, researchers or their representatives will be offered the opportunity to fly into Earth orbit and to perform their own experiments in orbit. These crew members' (called payload specialists) responsibilities will be experiment related only. These flights introduce an entirely new concept in flight crews and training concepts.

The requirement to train these individuals in the procedures for performing experiments in space presents a new and unique problem not satisfied by the training techniques employed for professional astronauts. This report defines a payload specialist training concept, and proceeds to provide an indepth training requirements analysis of selected missions. In addition, the results of a parametric analysis providing preliminary resource requirements are documented.

3.0 BACKGROUND

The Shuttle System is a transportation system designed to carry payloads to and from Earth orbit and to support in-orbit performance of experiments. The prime Shuttle payload, the only one discussed in this paper, is Spacelab. Spacelab has two major components, modules and pallets. The long pressurized module is 6.9 m (22.6 ft) long and 4.06 m (13.3 ft) in diameter, and pallets are in 3 m (9.8 ft) long segments. On a given mission, the Spacelab configuration can be comprised of a module only, a pallet(s) only, or a combination of module(s) and pallet(s). Experiment payloads may be contained in the module or mounted on the pallets for performance in Earth orbit.

Experiment payloads may be sponsored by any of a number of agencies including the Department of Defense (DOD), National Aeronautics and Space Administration (NASA), European Space Agency (ESA), or members of the scientific community such as universities or private research organizations. These payload sponsors or their designated researchers define, design, and develop experiment payloads for installation in a Spacelab with which to conduct in-orbit research of their choice.

To operate the Shuttle and its Spacelab payload, a crew consisting of a commander, a pilot, a mission specialist, and one to four payload specialists will be required.

1. Commander — The commander will be in command of the flight and will be responsible for the overall space vehicle operations, personnel, and vehicle safety.

2. Pilot — The pilot will be second in command of overall space vehicle operations. He will normally perform the payload deployment/retrieval operations via the remote manipulator system and will be the second crewman for EVA operations.

3. Mission Specialist — The mission specialist will be proficient in payload (experiment) operations. He will have a detailed knowledge of the payload operations, requirements, objectives, and supporting equipment. He will be knowledgeable on Orbiter and attached payload support systems and will be the prime crewman for EVA operations. At the discretion of the payload sponsor, he may assist in the management of payload operations and may in specific cases serve as the payload specialist.

4. Payload Specialist – The payload specialist will be responsible for the attainment of the payload (experiment) objectives. The payload specialist will have a detailed knowledge of the payload instruments (and their subsystems), operations, requirements, objectives, and supporting equipment. The payload specialist will be responsible for the management of payload operations and for the detailed operation of particular instruments or experiments. The payload specialist must be knowledgeable of certain Orbiter systems, e.g., accommodations, life support, hatches, tunnels, and caution and warning systems.

Because of the nature of their job the pilot, commander, and mission specialist will likely be selected from a cadre of professional astronauts. The mission specialist, pilot, and commander's duties are similar to astronaut duties of previous space missions, and training could be conducted in a similar way. However, the use of a payload specialist is a new concept, requiring the development of a different type of training program.

As a basic philosophy, Spacelab aims to open the space environment to researchers, i.e. principal investigators can be their own payload specialists. However, experience and preliminary planning indicate that the more usual or general case will be represented by the situation where a limited number of onboard specialists will be conducting research designed and sponsored by a larger number of ground-based principal investigators. While the specialists may, in general, begin with an overall discipline familiarity, they will seldom be proficient in the specific research which they will be called upon to conduct. Moreover, neither these "proxy" researchers nor principal investigators (should they be part of the payload specialist crew) will be aware of the operational ways in which their research interacts with other onboard activities.

From the outset it was recognized that all payload specialists would be required to undergo two basic kinds of training: mission independent and mission dependent. Certain background knowledge and skills must be shared by all payload specialists, regardless of the nature and objectives of their particular missions. This mission independent training embraces such areas as safety procedures, general payload carrier familiarization, system familiarization, habitability provisions and general flight procedures, and lends itself to a comparatively unvarying complement of training hardware, software, and other learning aids. There is a second, or mission dependent, category of training required – training tailored to the specific objectives and hardware to be operated on a particular mission. Clearly the training resources (hardware, software, and other learning provisions) to support this class of training will vary with each unique mission.

In the past, all training, including mission dependent training, was conducted with the aid of extremely high fidelity, "all up" trainers, duplicating to the highest practical extent all physical and operational aspects of the specific mission to be performed. After each mission, training systems were reconfigured to match the next upcoming mission. Given the overall successful record of America's space program, there can be no serious question as to the efficacy of this all-systems approach. It demands, however, either sufficient time between missions to either reconfigure hardware and then conduct training or, alternately, sufficient training resources to permit the conduct of multiple concurrent training operations. An early review of Spacelab operations indicated that the program would afford neither liberal time between missions nor the resources for multiple high-fidelity training facilities. For these reasons, an alternate approach was sought which would minimize program costs associated with multiple, high-fidelity trainers, provide the flexibility to support high frequency mission models, and yet provide payload specialists with a high degree of payload proficiency.

The training approach which was explored in depth (which came to be termed the "modular" approach) sought to abstract from a range of typical missions, the elements with which payload specialists would interact (e.g. payload specialist station, scientific airlock, racks, etc.). With these elements tabulated for each mission and with an analysis of how long a payload specialist would be required to train upon each element, various "mission models" were analyzed to assess resource requirements as a function of time. In a period of particularly high flight frequency where all missions are "complex" (demanding a lengthy training cycle for each), demands on certain resources may be quite high. A month or so later, however, the opposite situation might be true. Thus for each training resource a "resource profile" was produced for each of several mission models. After an examination of various scheduling options and the application of statistical and parametric analyses (described herein and in Reference 1), a recommendation for resource procurement was formulated.

It is reiterated that recommended resources are not at the whole trainer level, but rather at the element or module level. This implies that at least for the major part of their training, payload specialists will not be surrounded by a Spacelab pressure shell mockup with all internal features configured exactly as they will be encountered in flight. Rather, they will train on elements from their payload which can be progressively integrated such that ultimately all the operational elements with which they will deal will be physically present, but never in an exact physical duplicate of their flight Spacelab.

Some time prior to their flight, it will be highly desirable, or even necessary, to familiarize payload specialists with their unique Spacelab configuration. For the purposes of this study, it was postulated that there are at least two opportunities for this physical orientation to take place. For each payload to be assembled, a "soft mockup" will be constructed. This mockup, envisioned primarily as an aid to analytical integration, will be a three-dimensional plywood and cardboard layout of the payload. In this mockup the specialist can learn the relative locations of his research with respect to other onboard provisions, location of stowage of various elements, etc. Final physical orientation can take place on the flight hardware itself, after the Spacelab has been outfitted with all internal experiments and support provisions and with all items stowed in their appropriate locations (see Section 8.0, Note 1).

The analyses undertaken to define payload specialist mission dependent training resources required to help create the necessary level of competence is described below. Certain assumptions, drawn from extant policy and program goals, consistent with the preceding discussion guided the study. These included:

1. Payload specialists will be selected to satisfy payload sponsor requirements and although physical requirements for flight must be met, the payload specialist will not necessarily be a professional astronaut.

2. The payload sponsor has the primary responsibility for training payload specialists in the procedural aspects of the experiments. NASA's primary role is to facilitate training and to assist the payload sponsor in meeting his responsibility.

3. Mission dependent (experiment/Spacelab interface) training includes all training associated with the following:

a. Common payload support equipment familiarization.

b. Experiment operation to include operation through the CDMS console and payload specialist station.

c. Procedural training assistance when requested by the payload sponsor.

4. Mission independent (Orbiter/Spacelab systems) training will include:

a. Physiological conditioning.

b. Environmental familiarization.

c. Flight safety training (rescue procedures, survival equipment and procedures, inflight emergencies, pad egress).

d. Habitability (sleep, hygiene, eating, exercise).

e. Orbiter subsystems operation and characteristics (communication, life support, electrical power, attitude control, data management).

5. To preserve schedule integrity and provide maximum assurance that missions will be conducted by personnel of highest qualifications, a backup will be selected and trained for each payload specialist.

Based on these premises, the scope of this document is concept development and requirements analysis for payload specialist mission dependent training. The following sections define the proposed concept for payload specialist training and describe the analysis of resources required.

4.0 CONCEPT DEVELOPMENT

It is recognized that a training approach must produce payload specialist competent to perform Spacelab experiments and to contend with contingency situations. It is suggested that the use of a payload specialist modular trainer concept in conjunction with involvement in mission preparation activities will provide such a flexible and effective training program.

4.1 Modular Concept (see Section 8.0, Note 2)

A flexible, modular trainer concept requires the use of Spacelab component trainers such as airlocks, workbench, film vault/ stowage modules, racks, payload specialist station, and Command and Data Management System (CDMS) consoles. These items could be drawn upon to configure a training compartment for a particular experiment training exercise. At the same time other compartments could be configured for training on other experiments from that payload or for other payloads. Instead of a single trainer creating a queue for payload specialists, simultaneous training of several payload specialists could occur thus reducing cost and time while providing maximum trainer configuration flexibility.

Typically a payload specialist might be processed through the training facility as indicated in Figure 1. The orientation would give an overview of the Spacelab mission and its objectives as well as training objectives. A description of the facility would be provided together with an introduction to operational procedures to be followed. Also included in this orientation would be a presentation of each payload specialist's schedule for the training sessions. A tour of the facility would be conducted to orientate the payload specialist to the location of the various areas within the facility.

Figure 1. Typical training activities of payload specialist through training facility.

After training facility orientation, the payload specialists would spend a session in a flight configured soft mockup (wood and cardboard). This would allow them to locate their experiments within the Spacelab and in relation to other crewmen's experiments.

Each payload specialist would then complete a series of experiment specific training programs consisting of classroom and part task training exercises on each of his assigned experiments.

Following this a debriefing/evaluation period would occur where the payload sponsor identifies those areas in which he feels the payload specialist requires more training. The payload specialist would then receive additional training in those areas in which his performance is not adequate.

As a climax to the training exercise, the individual training compartment partitions would be removed as necessary and an integrated payload training session conducted involving all mission payload specialists. During this phase of training a Payload Operations Center (POC) would be interfaced with the training facility to simulate a ground/orbit interface.

4.2 Mission Activities Involvement

In addition to the formal training cycle, utilizing the concepts just described, payload specialist involvement in mission preparation activities can provide effective, realistic procedural and system interface training. Such mission activity involvement is essential to reduce payload specialist dedicated training time and training expense. Areas in which the payload specialist should be involved are experiment development and integration, mission and flight planning, and ground operations.

Experiment development and integration activities include the following:

1. Experiment design and fabrication

2. Experiment reviews

3. Experiment installation

4. Integration and acceptance reviews and tests.

Involvement in these activities would give the payload specialist an excellent background in the intricacies of experiment operation and interfaces.

Mission and Flight Planning activities include:

1. Discussion of mission objectives and constraints

2. Analysis of operations

3. Logistics and scheduling

4. Flight plan development

5. Onboard activity scheduling.

Active participation in these activities should provide the payload specialist with a good understanding of flight activities and objectives, and his responsibilities as payload specialist.

Payload specialist involvement in ground operations activities should include:

1. Subsystem and integrated systems tests

2. Payload/ Orbiter verification checks

3. Launch readiness reviews and tests.

This would provide a payload specialist interface with actual flight hardware as well as integrated activity with other crew members.

5.0 IDENTIFICATION OF TRAINING RESOURCES

The resources needed to support the modular concept of payload specialist training include facilities, hardware, and software. Each of the major items is defined in the following paragraphs.

5.1 Facilities

The types of facilities required are:

1. Classrooms — The classroom should provide an environment that allows the payload specialist to acquire an understanding of the requirements and obtain a basic knowledge of experiment operating capabilities and limitations.

Resources required for classroom support should include desks, chairs, chalkboards, flip chart boards, and other audio-visual aids such as overhead projectors, slide projectors, movie projectors, and audio tape recorders.

2. Part Task Compartments — In the part task area, the payload specialist develops a detailed understanding of hardware location, orientation, and configuration and obtains basic hands-on operational experience. It should be designed to support the payload specialist in developing the skills necessary for experiment performance and in developing crew coordination.

The part task areas should provide sufficient space and facilities to simulate Spacelab work stations. Spacelab similar racks should be utilized and the capability to interface rack mounted equipment to the CDMS should be provided. There will also be a requirement to link these areas to a simulation computer. A keyboard and CDMS console should be in close proximity to the part task trainer areas. There should be an audio communications link to the control room and video cameras should be mounted to allow observation of the area. These cameras should have pan-tilt-zoom capability and should be remote controlled from the control room. Facility interfaces such as power, vacuum, pressurant, etc. are undetermined. Partitions separating these areas should have the capability of easy and quick removal to allow for integrated flight simulation.

3. Control Room — The control room should contain training supervisor consoles which would provide for CCTV viewing of the part task area with TV cameras controllable from this console and select audio communication to all parts of the training facility and a POC. In addition, there should be a command keyboard which will permit experiment control and faulting via a simulation computer. Time display, video record capability, experiment and system data

display and other capabilities will be required. All video displays, closed circuit, and peripheral simulation video should be available at this console with superimposed time displays.

This console should also provide positions for payload sponsors to observe the training operation.

4. Maintenance and Storage — This area would be used for packing, unpacking, and inspection of experiment and simulation hardware. It supports part task preparation activities and provides an area for minor mechanical and electrical repair and refurbishment on a continuous basis. A security storage room would be required for special experiment hardware within this area.

5.2 Hardware

The major hardware components of training equipment required are the CDMS, simulation computers, Payload Specialist Station (PSS), peripheral simulation equipment, Common Payload Support Equipment (CPSE), and the part task experiments.

1. CDMS/CDMS Consoles — The training facility will require the use of a CDMS experiment computer capable of accepting flight type experiment software.

The CDMS should be accessed by a CDMS console, PSS, experiments, POC, and training control room. The information flowing from or to the PSS and/or the CDMS console is in the form of commands or information for display. The information from the CDMS to the POC and/or the training control room would be in the form of a data stream similar to the flight downlink. The information flowing from the POC and/or the training control room to the CDMS would be in the form of uplink commands. The data stream at the training control room would have to be processed to provide the same type displays as is provided for the payload sponsor at the POC. The data bus between the CDMS and the RAU's would carry experiment data and/or commands for experiment control.

2. Payload Specialist Station — One or more high fidelity representations of the Orbiter payload specialist station will be required for those missions operating with a pallet. It should provide a keyboard, TV monitor, analog-video recorder, caution and warning system and those experiment control and displays

required for that mission. It should be of flight size and functionally interact with the experiment and simulation computer. Audio and video links should be provided between this area and the control room.

3. Simulation Computer — A simulation computer (SimCom) equivalent to a Univac 1108 is required for support but could be shared with other tasks. This computer can be utilized to completely simulate experiments, when operational hardware is absent, through math models to generate stimulus to experiment hardware or to simulate experiment responses. The SimCom can be used to simulate portions of experiments not available, those experiments that cannot be operated in the Earth environment, as well as those experiments which can be simulated more cost-effectively than the experiment itself can be provided. The SimCom should also take commands from the training control room and impact the data to the experiment to evaluate the response of the trainee in non-nominal situations. The SimCom should interface with the CDMS, control room, part task area, PSS, and peripheral simulations in a control and data exchange capacity. The storage capacity for simulation programs is a function of the number of experiments being run simultaneously, the complexity of the experiment and the level of simulation required.

4. Peripheral Simulation Equipment — The peripheral simulation equipment would provide a visual training support to the payload specialist, e.g., deploying an antenna mounted on the pallet. This could be accomplished by a small model controlled by the SimCom with the trainee watching through a simulated viewport and an electrical feedback to signify when the antenna is fully deployed. Another type of peripheral simulation would be visual depictions displayed on CRT's mounted behind a viewport. Items such as clouds, star-fields and Earth targets could be displayed.

5. Common-Payload Support Equipment (CPSE) — The following items of common payload support equipment will be required: scientific airlock, viewport, and film vault. The viewports will be used in conjunction with peripheral simulation equipment to provide representative Earth, space and pallet views. In addition, a tunnel mock-up will be in this same area. All of these items will be of actual flight size.

6. Other Equipment — In addition to the major hardware items discussed, the following will be required:

a. Workbench — A trainer with high fidelity man/system interfaces will be required to familiarize the payload specialist with flight article operational interfaces.

b. Public Address (PA) System — A PA system throughout the training facility with the option to patch into the POC during integrated training sessions as required.

c. Experiment Support — Flight similar racks will be required for mounting user provided experiments. These racks must be portable and capable of accepting power and other facility supplied items.

5.3 Software Requirements

To provide a realistic training environment, the payload specialist should interact with data representative of what might be seen in flight. Much of this data presentation will be generated by software packages.

Data gathering and transmitting activities of pallet mounted sensors can be simulated by software packages. These software packages should be generated for each major sensor element for all disciplines to form a stimulus simulation library. By this method, the establishment of pertinent mission parameters (altitude, pointing attitude, solar activities, etc.) should provide enough information for the software to simulate an instrument's activities and generate appropriate data to the payload specialist. This software should simulate experiment data flow through the experiment data bus and provide logic to allow experiment interaction by payload specialist, ground flight control, or the training supervisor. The data that would normally be on the high rate data bus should be simulated as downlinked at the user console in the format in which it would appear in flight.

Software programs will also be required to simulate outputs of experiment equipment that cannot be furnished during the training period. It must also support special purpose peripheral simulations, i.e. star fields, Earth views.

Specific software package requirements and sizing are undefined at present. Future analysis is planned for this area.

6.0 ANALYSIS

The previous sections describe the proposed payload specialist training concept and the types of resources required to support the formal training period. To establish the overall requirements of such a concept and to quantify the resources necessary to support this training system, an analysis and computerized modeling study was performed.

The purpose of this study was to define typical overall mission training requirements in terms of the modular trainer concept and resources as defined, then to quantify the resource requirements for a variety of flight frequency and training experience possibilities.

The steps involved in this analysis and the results achieved are discussed in detail in the following paragraphs. The overall flow of activities performed is shown in Figure 2.

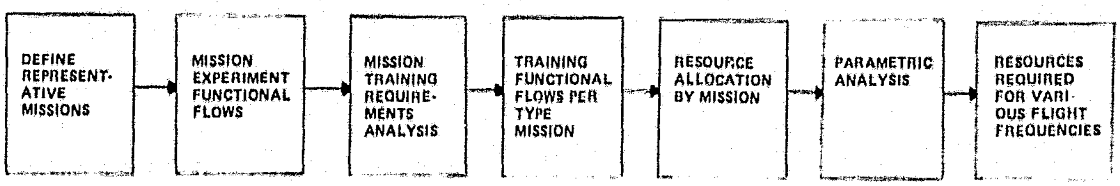


Figure 2. Training requirements analysis flow.

6.1 Typical Mission Definition

Since training resource requirements are directly related to the payload complement for which training must be provided, any analysis of the situation must be tied as closely as possible to realistic Spacelab payloads. Spacelab payload definitions at this time are mostly in the form of reference mission data, or specific experiment data.

The primary sources of experiment and mission data for Spacelab are described in Table 1. References 2 through 11 were utilized to support this analysis.

From this reference material [1-11], a set of four missions was chosen for detailed analysis. The missions chosen were:

TABLE 1. SPACELAB MISSION AND EXPERIMENT DATA SOURCES

1. Space Shuttle Payload Description (SSPD)

The SSPD contains the results of a survey by MSFC of the scientific community of potential payload sponsors. They were asked to describe what experiments they would like to fly on the Shuttle. The data are accumulated according to scientific discipline and include the following information for each experiment:

Payload Operator Skill Requirements
Launch and Orbital Requirements
Payload Objective
Experiment Hardware Description
Payload Interface with Space Vehicles
Power, Data, and Environmental Requirements
Operational Times and Crew Involvement
Stowage Requirements
Computer Support Requirements

This information is available on anticipated Spacelab experiments but the data are not grouped into missions or payloads.

2. Integrated Mission Planning (IMAP) Document

The IMAP exercise constructs reference missions by combining selected SSPD payloads. These analysis and planning procedures provide experience and data on activities required for flight definition. The IMAP is an integrated compilation of in-depth studies to assess the feasibility of reference missions by a number of technical discipline organizations. These disciplines include flight operations, mission timelines, associated ground operations, vehicle/payload interface, and payload analysis.

3. Operation Requirements Analysis (ORA)

The purpose of the ORA is to define, in as feasible detail as possible, those requirements for Spacelab experiments operations as performed during the mission. The ORA identifies on-orbit crew operations as well as ground operations required of a payload operations control center. An ORA form lists the flight/support function and associated skill, manpower and time requirements, hardware, and interface requirements.

Mission 10: Multidiscipline — Pallet only

Mission 11: Multidiscipline — Lab and Pallet

Mission 14: Dedicated — Lab only

Mission 19: Dedicated — Lab and Pallet

These missions were selected as representative of the spectrum of possible Spacelab configurations and of the various scientific disciplines planned for Spacelab flight. From a training standpoint, these missions should bound the training problem from a simple set through a complex set of training requirements as defined in the following sections. The missions selected and their experiments are given in Table 2.

6.2 Mission Experiment Functional Flow Development

A detailed analysis of the training requirements for each mission was performed. The first step in the training requirements analysis was the development of Level I functional flow diagrams (Fig. 3). These top level flows contain the gross functions to be performed during the actual flight experiment operation phase and are a direct output of the ORA. These functional diagrams are developed for the primary purpose of structuring system requirements into functional terms.

These are further expanded into Level II functions or tasks. The Level II functions are the lowest level necessary to establish the requirements of training resources for a given experiment which makes up a part of a payload.

6.3 Mission Training Requirements Analysis

The training requirements analysis form is illustrated in Figure 4. It provides detailed information on each Level II function which must be performed in conducting an experiment or group of experiments and what training resources and time is required to train for that function. Each field on the form is defined below:

1. Function — The function lists the Level II function to be performed for which this sheet defines the requirements.

2. Number of Payload Specialist — This is the number of payload specialists to be trained to perform the function.

TABLE 2. TRAINING ANALYSIS MISSIONS

Mission 10: Multidiscipline Pallet Only	
EO-19-S	High Speed Interferometer
AP-04-S	Gravity and Relativity Satellite
HE-11-S	High Energy Astrophysics
SO-17-S	Solar Activity Growth Processes
Mission 11: Multidiscipline Lab and Pallet	
XST 001	Microwave Interferometer
XST 004	Autonomous Navigation
XST 006	Search and Rescue
XST 008	Imaging Radar
XST 010	Lidar
XST 019	Ultraviolet Meteor Spectroscopy
XST 020	Colony Growth in Zero-G
XST 021	Interpersonal Transfer of Microorganisms in Zero-G
XST 023	Electrical Characteristics of Biological Cells
XST 024	Special Properties of Biological Cells
XST 026	Zero-G Steam Generator
XST 027	Sampling of A/B Particles
XST 029	Environmental Effects on Nonmetals
XST 040	External Contamination Measurements
Mission 14: Dedicated Lab (Life Sciences)	
LS-09-S	Medical Emphasis Mission (medicine, biology, life support and protective systems, man systems integration)
LS 001	Visual Records and Microscope
LS 002	Data Management Unit
LS 003	Life Sciences Support Unit
LS 004	Preparation and Preservation Unit
LS 005	Biochemical/Biophysical Analysis Unit
LS 006	Maintenance, Repair and Fabrication Unit
LS 007	Ancillary Storage
LS 012	Biomed/Behavioral Measurements Unit

TABLE 2. (Concluded)

Mission 14: Dedicated Lab (Life Sciences) (Concluded)	
LS 023	Internal Centrifuge
LS 026	Radiobiology Unit
LS 031	Biomed. Support Unit
LS 040/041	Vertebrate Holding Unit
LS 042	Vertebrate Support Unit
LS 060/061	Cells and Tissues Holding and Support Unit
Mission 19: Dedicated Lab and Pallet (Atmospheric, Magnetospheric and Plasmas in Space)	
XAP 410	Wave Characteristics
XAP 420	Wave/Particle Interactions
XAP 430	Wake and Sheath Experiments
XAP 450	Global Emission Survey
XAP 470	Magnetospheric Topology

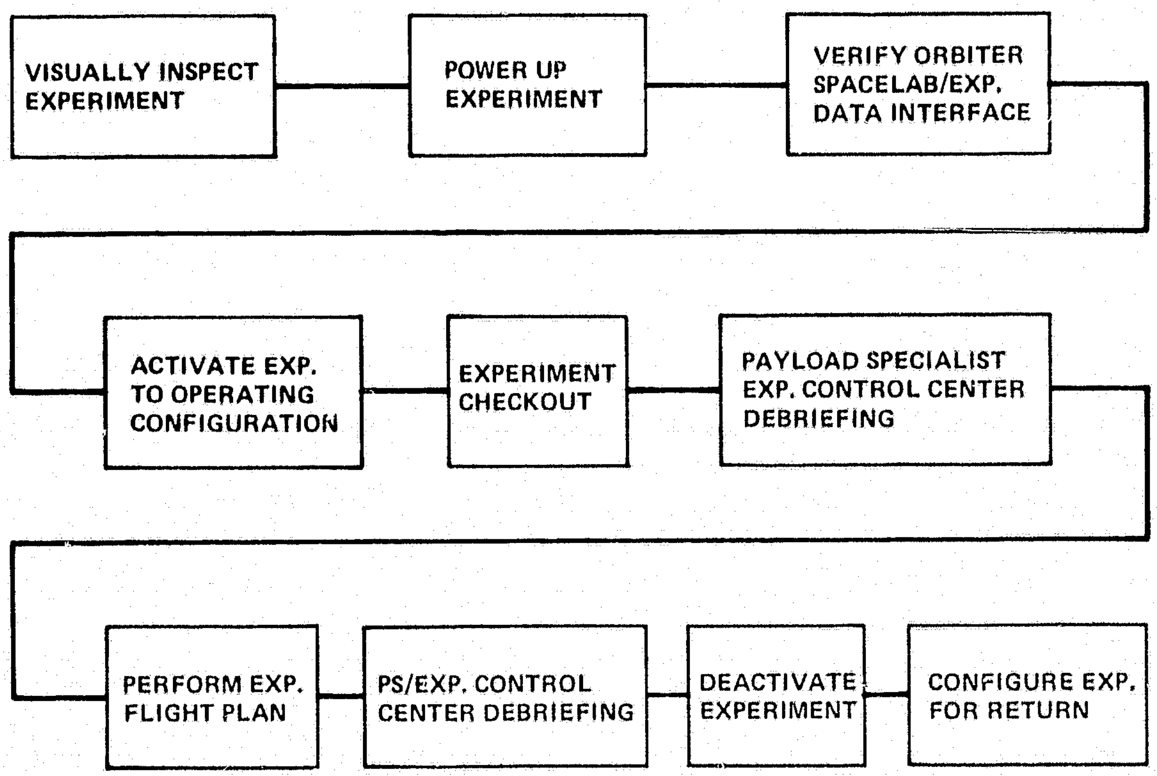


Figure 3. Level I functional flow diagram.

PAYLOAD SPECIALIST TRAINING REQUIREMENTS

FLIGHT 19c PAYLOAD AP-06S

EXPERIMENT XAP-410

SHEET NO.____ OF ____

1 FUNCTION	2 NO. P.S.	3 KNOWLEDGE	4 SKILL	5 TRAINING METHODS	6 LEVEL	7 TRAINING HOURS: NO PREV. TRNG	7 TRAINING HOURS: PREV. TRNG	11 REMARKS
6.3 Deploy subsatellite antenna/boom	2	• Panel location • Panel layout • Deployment Procedures • Expeeted values • CCTV operations (Ref)	• Switch activation • Display interpretation	• Classroom - panel location layout and procedures familiarization	Proficient	0.3	0.2	
				• Part-task m/u w/sim computer		0.5	0.4	

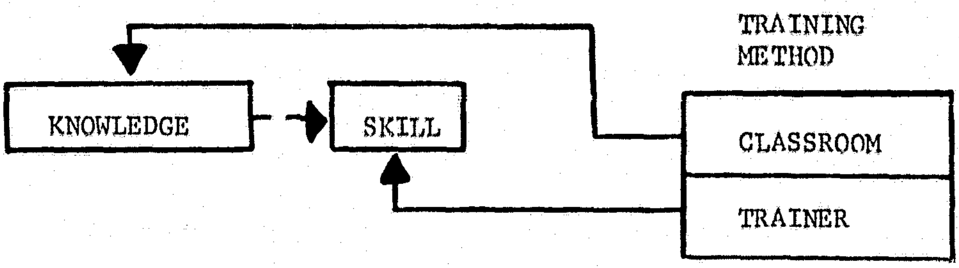
8 MOCKUPS	9 DATA SYSTEMS	10 PERIPHERAL SIMULATION HARDWARE	11 REMARKS
PART TASK: 1-rack w/subsatellite antenna and boom C&D panel and CCTV monitor	COMPUTER SYSTEMS Simulate boom/antenna extension procedural responses to C&D	1-film used with CCTV system illustrating via CCTV monitor antenna/boom deployment	Data system and peripheral simulation film must be coordinated with one another.
FULL:			
SOFT:	INTERFACING EQUIPMENT		
NB			
ZERO-G			
RACK 1			
CPSE	SOFTWARE Program to simulate antenna/boom deployment responses to C&D.		
C&D 1-subsatellite antenna/boom C&D panel 1-CCTV monitor & controls			
OTHER			

Figure 4. Training requirements analysis form.

3. Knowledge — This field identifies the knowledge required to perform the function. This includes primarily knowledge not expected to be part of a payload specialist's background and which must be imparted either by experimenters whom the payload specialist will represent and/or by the host payload center.

4. Skill — Skill refers to the ability to perform specific tasks. This field identifies the operational skills necessary to perform the function at the necessary level of proficiency.

5. Training Methods — This field identifies the most appropriate methods of training to perform this function. The two basic methods available for training are classroom and trainer. These methods relate back to knowledge and skill as shown in the following diagram.



That is, classroom training imparts knowledge while trainer experience (utilizing knowledge gained) imparts skill.

Classroom training will be conducted to sufficient depth to minimize the use of trainers for other than the acquisition of skill (e.g., speed, precision, etc.). The training hours (item 7) for classroom and trainer reflect this philosophy.

6. Level — The level defines the function performance proficiency required. This is categorized as Limited, Proficient, Competent, or Highly Proficient according to the following definitions.

Level	After Training Payload Specialist Will be Able to:
Limited	Accomplish most task activities by being told or shown how
Proficient	Accomplish most of the task or activity, but not necessarily to desired levels of speed or accuracy
Competent	Accomplish a task or activity at minimum acceptable levels of speed or accuracy
Highly Proficient	Accomplish an activity at highest levels of speed or accuracy, and be able to tell or show others how to do the activites

7. Training Hours — This field defines the number of training hours required of each training method (item 5) to train all payload specialist identified in item 2. This information is provided for two different types of payload specialists:

a. No Previous Training — Assumes the payload specialist has never been previously trained to perform Spacelab experiments.

b. Previous Training — Assumes all payload specialists have previously been trained to perform Spacelab experiments, although not necessarily this particular function.

8. Mockups — This field defines the type of mockup trainer or hardware required to train the payload specialist to perform this function. The options are:

a. Part Task — Part Task Trainer

b. Full — Engineering Model

c. Soft — Spacelab module trainer soft mockup

d. NB — Neutral Buoyancy simulator

e. Zero-G — KC 135 aircraft zero-gravity simulator

f. Racks — Number of racks necessary

g. CPSE — Common Payload Support Equipment such as short airlock, long airlock, viewport, film vault.

h. C&D — Control and display panels on consoles. To perform tasks the payload specialist must interact with various experiment related C&D. Since there is no current detailed definition of these C&D elements, five categories of increasing complexity were defined for purpose of scoping simulation requirements:

Category	Description
A	Discrete: 1-10 channels
B	Discrete: 11 or more channels
C	Variable, i.e., meters, CRT's
D	Requires computer simulation or feedback
E	Requires CDMS, keyboard, and CRT. Payload specialist panel requires one Type E; a CDMS console, two Type E's
Other	Stowage module, experiment hardware, workbench

9. Data Systems — Defines the computer systems, interfacing equipment, and software required to train for this function. Where known, data quantity and time of actual computer usage are given. Interfacing equipment is limited to RAU's or hardware used to simulate a RAU function. A preliminary statement of software requirements for the simulation computer are shown for each function. This identifies those programs necessary to simulate experiments or experiment responses.

10. Peripheral Simulation Hardware — Any equipment used for peripheral simulations, such as video system to show stars, Earth targets, clouds, etc., will be defined for the function.

11. Remarks — Additional information pertinent to the function are given here such as coordination requirements or other special requirements.

This detailed information was prepared for each Level II function of each experiment of a mission. In addition an experiment summary sheet was prepared which compiles the training resource requirements and associated usage time for the entire experiment.

6.4 Mission Functional Flows

From the detailed training requirements analysis and associated summaries, a training functional flow was developed for each mission (Fig. 5).

This flow depicts a scheduling of training necessary to achieve the results defined in the summary of the training requirements analysis and presents a profile of training resource utilization for that training time period. To alleviate computer overloading, training is scheduled such that while part of the crew is in the trainer performing experiments with computer usage, others are performing classroom training without computer usage on another experiment.

6.5 Parametric Analysis of Resource Requirements

Training facility requirements are dependent on flight frequency, payload type, training period, and payload specialist experience ratio. For high flight frequencies, the training sessions will overlap and facility requirements will be the sum of each flight's resource requirements. To identify these requirements, the mission functional flow data for each representative mission were loaded into a data base for use by a computer parametric model. This model randomly schedules the representative flights to meet the specified flight frequency. To allow crew involvement in ground operations tests, the payload specialist training must essentially terminate 4 weeks prior to launch. Thus if we look at the random scheduling of flights, it might appear as in Figure 6. The following parameters may be varied in the computer analysis:

1. Flight frequency (2-32 flight/year)

2. Training periods (40 or 56 h/wk/crew)

3. Payload specialist experience ratio (100 percent naive to 0 percent naive in 20 percent increments).

After defining these parameters, the computer randomly schedules the representative flights to satisfy the chosen flight frequency and prints out a daily schedule of training resources required to support training for all flights in

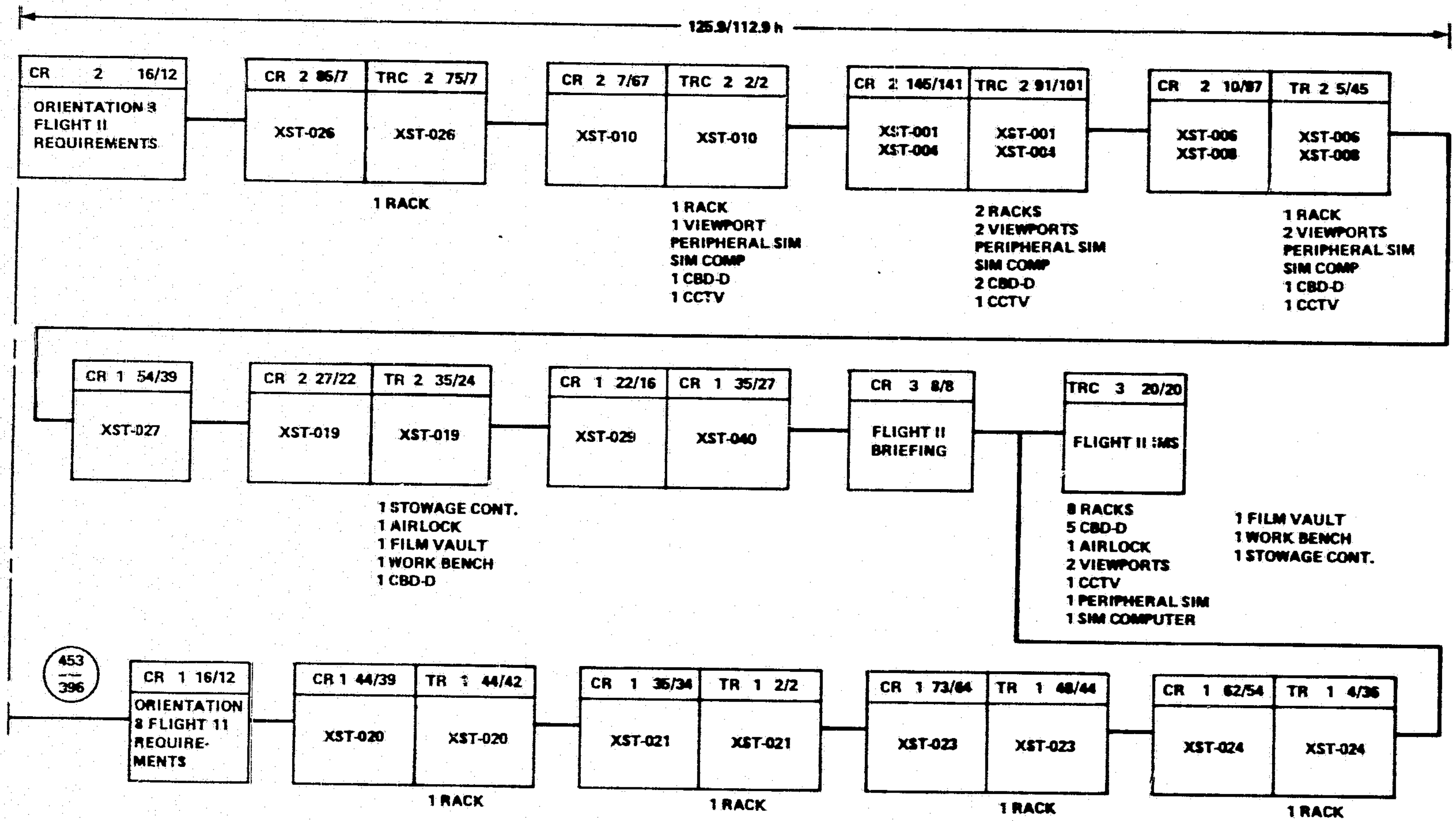


Figure 5. Flight 11 training block diagram.

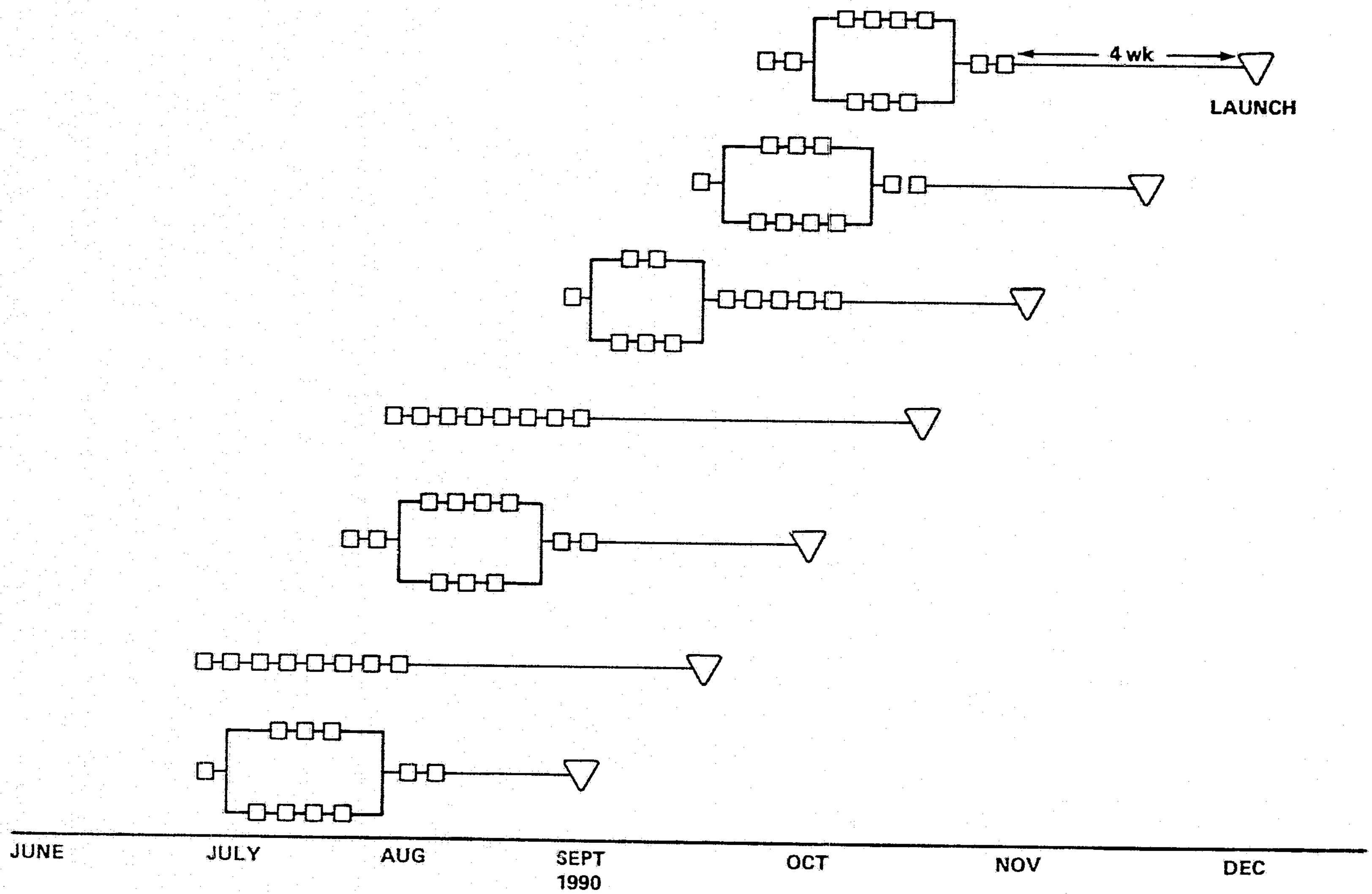


Figure 6. Representative training schedule.

process at that time. For example, if we wished to look at the case of 12 flights/year, 40 h/wk training, and 80 percent naive and 20 percent experienced crew, the computer would schedule the 12 launches on equal centers (one month apart) and sum training hardware requirements for each day of the year (appendix).

To gain more confidence in the data, 50 random flight sequences for each case were averaged by day. Requirements for each piece of training hardware were then plotted in the form of a cumulative frequency distribution (Fig. 7). Using the plot of racks as an example, one can see that for the specified conditions 32 racks will satisfy more than 95 percent of the training requirements. Similar plots for all of the resources scope the training resource problem for flight frequencies from 1 through 32 flights/year. These data are summarized in Table 3.

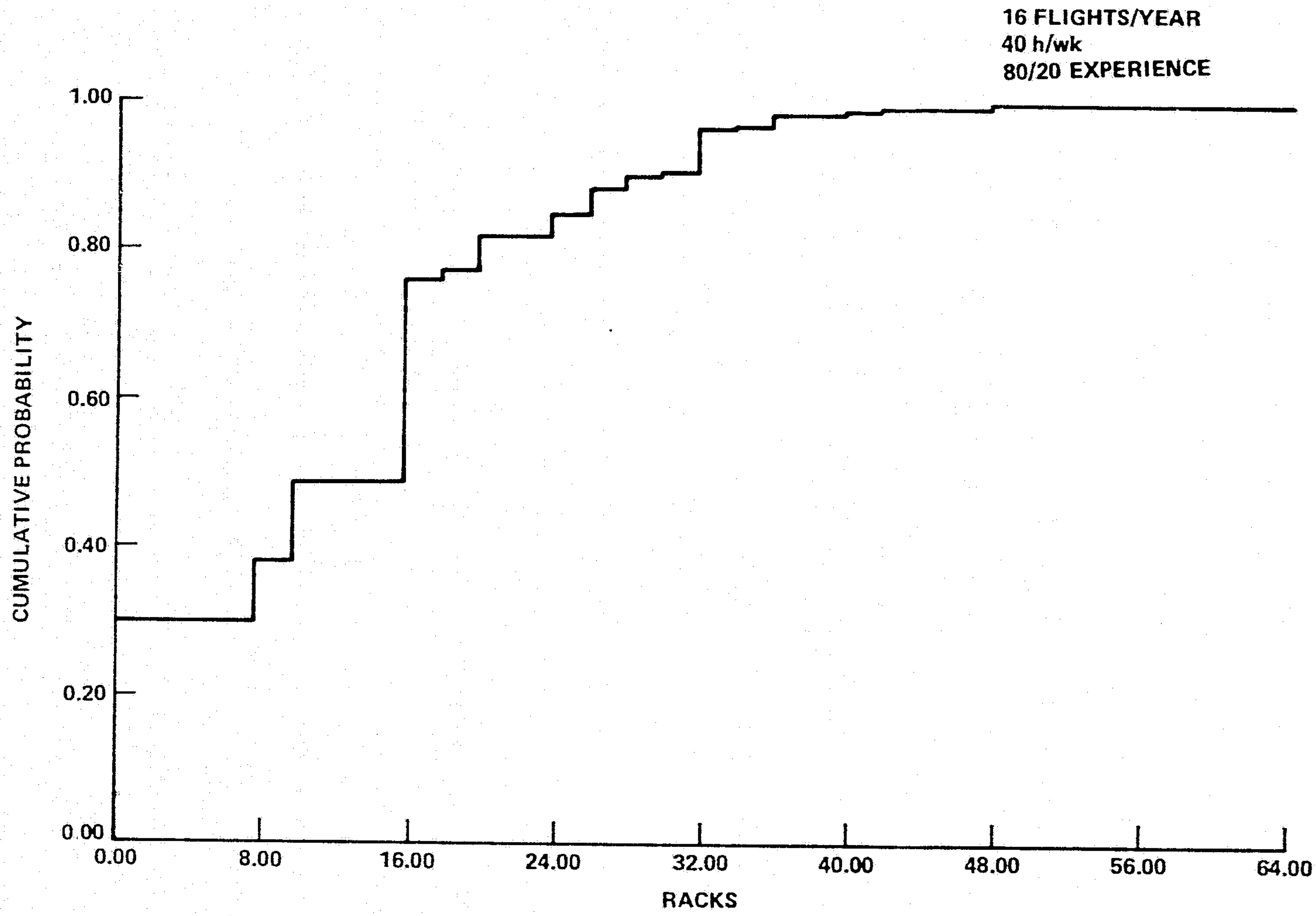


Figure 7. Racks.

TABLE 3. FLIGHT DATA

Resources	Flights/Year					
	1	4	8	16	24	32
Racks	8	8	16	32	32	40
PSS	1	1	1	1	1	1
Airlocks	1	1	1	1	1	1
Viewports	2	2	2	2	2	2
A Panels	2	3	12	18	20	24
B Panels	2	2	2	3	3	3
C Panels	2	2	3	3	4	5
D Panels	4	4	6	10	14	16
E Panels	2	2	2	4	4	4

7.0 CONCLUSIONS

Those resources shown in Table 3 will satisfy 95 percent of all parametrically identified requirements for the respective flight frequencies. To satisfy these same requirements could require as many as four full trainers at a cost several magnitudes greater than that required for the modular concept. The modular concept provides the flexible low cost and time saving approach needed to satisfy a multipurpose, high throughput training situation.

While our analysis has scoped the problem, there are still refinements and additional areas requiring study.

None of our original analysis made use of scheduling optimization algorithms to allow a reduction in training times per mission. Training resource requirements were not analyzed to the detail of shifting mission training start dates to reduce overlaps in training sessions which in turn might reduce resource requirements.

For analysis simplicity, facility preparation requirements were not considered in evaluation of resource requirements in this study. It is recognized that trainers must be configured for the various flights and such configuring ties up resources prior to the actual training start date.

For this analysis, flights were randomly scheduled. There are now, however, realistic mission models which schedule flights by discipline throughout the 1980-1990 time frame. A more realistic analysis could be performed by analyzing training requirements to meet this mission model.

Very little attention was given to the concept of learning curves throughout our analysis. This needs consideration to determine if such impacts have significant effects on the analysis.

All of these areas have received analysis since our initial studies and will be the subject of a subsequent report.

8.0 NOTES

(1) At an early stage, one concept which was explored centered a large portion of active training taking place on the flight Spacelab. The main reasons for discarding this notion included incompatibilities with integration schedules, the imposition of increased "wear and tear" on flight systems, the inability to introduce training peculiar "faults" into system operation, and the inability to simulate weightless operation with "real" hardware.

(2) In an attempt to evaluate the modular concept, it was applied to the extent possible in training for a Concept Verification Test (CVT) mission. A dedicated Material Science Mission (CVT IV A) was performed by a naive crew totally trained by various experiment PI. Each crewman and backup were trained on their assigned experiments in the PI Laboratory on the actual hardware separately from the other crewman. Following the individual experiment training, an integrated simulation was performed in the test vehicle (General Purpose Laboratory) prior to the start of the actual test week.

In spite of many PI scheduling conflicts and initial lack of completely assembled hardware, crew performance was successful during the mission. Crew members were able to complete repairs and conduct procedural changes during the test with verbal assistance from the PI. It can be concluded from this test that:

1. Separate training for each payload specialist on his assigned experiments is acceptable.

2. An integrated payload simulation is essential to learning of relationships and constraints of other experiments and surrounding environments.

3. PI may prove too busy with other activities to adhere to an established training schedule. This may necessitate the establishment of a dedicated training staff.

A more detailed description of the CVT IV A test results is contained in the final report available from the MSFC CVT Office.

REFERENCES

1. Spacelab Mission Dependent Training Parametric Resource Requirements Study, MSFC TM X-64979.

2. Harry Watters to Distribution: Spacelab Payload Specialist Training Concept Definition. MSFC Memorandum EL15 (75-03), Mar. 12, 1975.

3. Thomason, H. E. and McQueen, J. A.: Summary of Mission 10, Spacelab — Pallet Only High Energy Astrophysics Experiments Deploy Gravity and Relativity Satellite Solar Activity Growth Processes High Speed Interferometer. MSFC unnumbered report, Preliminary, May 16, 1975.

4. Integrated Mission Planning First Two Years of Shuttle Missions 1970-1980. MSFC unnumbered report, Program Development Directorate (Mission 11), Mar. 1974.

5. Thomason, H. E. and McQueen, J. A.: Mission 12 Summary — Spacelab Life Sciences Mission Life Sciences Space Laboratory Teleoperator Orbiter Bay Experiment Deploy Sexsat Satellite. IMAP, MSFC Report SE012-012-2H, July 1975.

6. Thomason, H. E. and McQueen, J. A.: Mission 12 Technical Report — Spacelab — Life Sciences Mission, Life Sciences Space Laboratory, Teleoperator Orbiter Bay Experiment, Deploy Sexsat Satellite. MSFC Report SE012-013-2H, July 1975.

7. Thomason, H. E. and McQueen, J. A.: Mission 19 Summary — Spacelab — Module and Pallet Atmospheric, Magnetospheric and Plasmas in Space (AMPS). MSFC Report SE-012-010-2H, May 1975.

8. Thomason, H. E. and McQueen, J. A.: Mission 19 Technical Report, Spacelab — Module and Pallet, Atmospheric, Magnetospheric and Plasmas in Space (AMPS). MSFC unnumbered report, May 1975.

9. Shuttle Payload Activities Ad Hoc Team. Donlan Committee Report, April 1974.

REFERENCES (Concluded)

10. NASA Program/Project Approval Document Research and Development Hardware Development/Flights. NASA Document MSF-IX96-SL/CVT, September 17, 1973.

11. Spacelab Programme Requirements Level 1. ESRO-SL-74-1, NASA-MF-74-1, March 5, 1974.

APPENDIX

PARAMETRIC ANALYSIS RESULTS
12 Flights/Year

MISSION SCHEDULE

12 LAUNCHES/YR   EXPERIENCE 80/20
40 HOURS/WK   RUN CODE 79634

FLIGHT	TRAINING START DAY	TRAINING STOP DAY	LAUNCH DAY
11	355	12	31
DC	18	40	61
14	46	71	91
10	85	103	122
8	82	121	152
11	143	164	182
8	144	180	213
12	192	220	243
8	206	242	273
DD	282	292	304
19	262	299	334
12	313	341	364

TRAINING EQUIPMENT REQUIREMENTS   12 LAUNCHES/YR   EXPERIENCE 80/20
40 HOURS/WK   RUN CODE 79634

			CONTROLS AND DISPLAYS					AIR-	VIEW-		PERIPHERAL
DAY	RACKS	PSS	A	B	C	D	E	LOCKS	PORTS	CCTV	STIMULATORS
1	8	0	0	0	0	0	0	0	0	0	0
2	8	0	0	0	0	2	0	0	2	1	1
3	8	0	0	0	0	2	0	0	2	1	1
4	8	0	0	0	0	0	0	0	0	0	0
5	8	0	0	0	0	1	0	0	2	1	1
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	8	0	0	0	0	1	0	1	0	0	0
9	8	0	0	0	0	0	0	0	0	0	0
10	8	0	0	0	0	5	0	1	2	1	1
11	8	0	0	0	0	5	0	1	2	1	1
12	8	0	0	0	0	5	0	1	2	1	1
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0
24	7	0	3	0	0	1	0	0	0	0	0
25	7	0	0	0	0	1	0	0	0	0	0
26	7	0	0	0	0	1	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0
29	7	0	2	0	0	1	0	0	0	0	0
30	7	0	2	0	0	1	0	0	0	0	0
31	7	0	0	0	0	0	0	0	0	0	0
32	7	0	0	0	0	0	0	0	0	0	0
33	7	0	0	0	1	0	1	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0
36	7	0	0	0	0	0	0	0	0	0	0
37	7	0	0	0	1	0	1	0	0	0	0
38	7	0	5	0	1	4	1	0	0	0	0
39	7	0	5	0	1	4	1	0	0	0	0
40	7	0	5	0	1	4	1	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0

TRAINING EQUIPMENT REQUIREMENTS — 12 LAUNCHES/YR — EXPERIENCE 80/20
40 HOURS/WK — RUN CODE 79634

			CONTROLS AND DISPLAYS					AIR-	VEIW-		PERIPHERAL
DAY	RACKS	PSS	A	B	C	D	E	LOCKS	PORTS	CCTV	SIMULATORS
47	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0
52	0	0	3	0	0	1	0	0	0	0	0
53	8	0	5	0	0	2	0	0	2	0	1
54	8	0	2	0	0	1	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0
57	0	0	2	0	0	1	0	0	0	0	0
58	8	0	5	0	0	1	0	0	2	0	1
59	0	0	3	0	0	2	0	0	1	0	1
60	8	0	0	0	0	0	0	0	0	0	0
61	8	0	5	0	0	2	0	0	2	0	1
62	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0
64	8	0	0	0	0	0	0	0	0	0	0
65	8	0	23	0	0	14	0	0	2	0	2
66	8	0	23	0	0	14	0	0	2	0	2
67	8	0	23	0	0	14	0	0	2	0	2
68	8	0	23	0	0	14	0	0	2	0	2
69	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0
71	8	0	23	0	0	14	0	0	2	0	2
72	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0
87	10	0	0	0	0	1	0	0	1	0	1
88	10	0	0	0	0	1	0	0	1	0	1
89	10	1	0	0	1	0	2	0	1	1	1
90	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	0
92	10	0	0	0	0	3	0	0	1	0	1

TRAINING EQUIPMENT REQUIREMENTS　　　12 LAUNCHES/YR　　EXPERIENCE 80/20
40 HOURS/WK　　RUN CODE 79634

DAY	RACKS	PSS	CONTROLS AND DISPLAYS A	B	C	D	E	AIR-LOCKS	VEIW-PORTS	CCTV	PERIPHERAL SIMULATORS
93	10	1	0	0	1	3	2	0	2	1	2
94	10	1	0	0	1	3	2	0	2	1	2
95	10	1	0	0	1	1	2	0	1	1	1
96	10	0	0	0	0	1	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0
98	0	0	0	0	0	0	0	0	0	0	0
99	10	1	1	0	2	0	3	0	1	1	1
100	10	1	1	0	2	0	3	0	1	1	1
101	10	1	1	0	2	0	3	0	1	1	1
102	10	1	1	0	2	0	2	0	1	1	1
103	10	1	1	0	2	0	3	0	2	1	2
104	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0
106	10	0	8	0	0	2	0	0	1	0	1
107	10	0	2	0	0	1	0	0	0	0	0
108	10	0	2	0	0	1	0	0	0	0	0
109	10	0	3	0	0	1	0	0	0	0	0
110	10	0	0	0	0	1	0	0	0	0	0
111	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0
113	10	0	0	0	0	1	0	0	0	0	0
114	10	0	0	0	0	0	0	0	0	0	0
115	10	0	13	0	0	9	2	0	1	0	1
116	10	0	13	0	0	9	2	0	1	0	1
117	10	0	13	0	0	9	2	0	1	0	1
118	0	0	0	0	0	0	0	0	0	0	0
119	0	0	0	0	0	0	0	0	0	0	0
120	10	0	13	0	0	9	2	0	1	0	1
121	10	0	13	0	0	9	2	0	1	0	1
122	0	0	0	0	0	0	0	0	0	0	0
123	0	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	0	0	0	0	0
126	0	0	0	0	0	0	0	0	0	0	0
127	0	0	0	0	0	0	0	0	0	0	0
128	0	0	0	0	0	0	0	0	0	0	0
129	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0
132	0	0	0	0	0	0	0	0	0	0	0
133	0	0	0	0	0	0	0	0	0	0	0
134	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0
137	0	0	0	0	0	0	0	0	0	0	0
138	0	0	0	0	0	0	0	0	0	0	0

TRAINING EQUIPMENT REQUIREMENTS — 12 LAUNCHES/YR — EXPERIENCE 80/20
40 HOURS/WK — RUN CODE 79634

			CONTROLS AND DISPLAYS					AIR-	VEIW-		PERIPHERAL
DAY	RACKS	PSS	A	B	C	D	E	LOCKS	PORTS	CCTV	SIMULATORS
139	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	0	0	0
142	0	0	0	0	0	0	0	0	0	0	0
143	0	0	0	0	0	0	0	0	0	0	0
144	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0
147	0	0	0	0	0	0	0	0	0	0	0
148	8	0	0	0	0	0	0	0	0	0	0
149	18	0	0	0	0	1	0	0	1	0	1
150	18	0	0	0	0	2	0	0	2	1	2
151	18	0	0	0	0	0	0	0	0	0	0
152	18	0	0	0	0	5	0	0	3	1	2
153	0	0	0	0	0	0	0	0	0	0	0
154	0	0	0	0	0	0	0	0	0	0	0
155	18	0	0	0	0	5	0	0	3	1	2
156	18	0	0	0	0	4	0	0	3	1	2
157	18	0	0	0	0	1	0	0	0	0	0
158	18	0	0	0	0	2	0	1	0	0	0
159	18	0	0	0	0	0	1	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	0	0	0
162	18	0	0	0	0	5	1	1	2	1	1
163	18	0	0	0	0	5	1	1	2	1	1
164	18	0	0	0	0	5	0	1	2	1	1
165	10	0	0	0	0	0	1	0	1	0	1
166	10	0	8	0	0	2	0	0	1	0	1
167	0	0	0	0	0	0	0	0	0	0	0
168	0	0	0	0	0	0	0	0	0	0	0
169	10	0	2	0	0	1	0	0	0	0	0
170	10	0	0	0	0	0	0	0	0	0	0
171	10	0	3	0	0	1	0	0	0	0	0
172	10	0	0	0	0	1	0	0	0	0	0
173	10	0	0	0	0	0	0	0	0	0	0
174	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0
176	10	0	13	0	0	9	2	0	1	0	1
177	10	0	13	0	0	9	2	0	1	0	1
178	10	0	13	0	0	9	2	0	1	0	1
179	10	0	13	0	0	9	2	0	1	0	1
180	10	0	13	0	0	9	2	0	1	0	1
181	0	0	0	0	0	0	0	0	0	0	0
182	0	0	0	0	0	0	0	0	0	0	0
183	0	0	0	0	0	0	0	0	0	0	0
184	0	0	0	0	0	0	0	0	0	0	0

TRAINING EQUIPMENT REQUIREMENTS — 12 LAUNCHES/YR — 40 HOURS/WK — EXPERIENCE 80/20 — RUN CODE 79634

DAY	RACKS	PSS	CONTROLS AND DISPLAYS A	B	C	D	E	AIR-LOCKS	VEIW-PORTS	CCTV	PERIPHERAL SIMULATORS
185	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0	0	0	0	0	0	0	0
187	0	0	0	0	0	0	0	0	0	0	0
188	0	0	0	0	0	0	0	0	0	0	0
189	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0	0
192	0	0	0	0	0	0	0	0	0	0	0
193	0	0	0	0	0	0	0	0	0	0	0
194	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0	0	0	0
197	0	0	0	0	0	0	0	0	0	0	0
198	0	0	0	0	0	0	0	0	0	0	0
199	16	0	1	2	3	2	2	0	0	1	0
200	16	0	1	2	3	2	2	0	0	1	0
201	16	0	1	2	3	2	2	0	0	1	0
202	0	0	0	0	0	0	0	0	0	0	0
203	0	0	0	0	0	0	0	0	0	0	0
204	16	0	1	2	3	2	2	0	0	1	0
205	16	0	1	2	3	2	2	0	0	1	0
206	16	0	1	2	3	2	2	0	0	1	0
207	16	0	0	0	0	0	0	0	0	0	0
208	26	0	0	0	0	1	0	0	1	0	1
209	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0
211	26	0	0	0	1	4	1	0	1	0	1
212	26	0	0	0	1	3	1	0	0	0	0
213	26	0	0	0	1	6	1	0	1	0	1
214	26	0	0	0	1	6	1	0	1	0	1
215	26	0	0	0	1	6	1	0	1	0	1
216	0	0	0	0	0	0	0	0	0	0	0
217	0	0	0	0	0	0	0	0	0	0	0
218	26	0	0	0	0	1	0	0	0	0	0
219	26	0	1	2	4	6	3	0	0	1	0
220	26	0	1	2	4	5	4	0	0	1	0
221	10	0	0	0	0	0	1	0	0	0	0
222	10	0	0	0	0	0	1	0	0	0	0
223	0	0	0	0	0	0	0	0	0	0	0
224	0	0	0	0	0	0	0	0	0	0	0
225	10	0	0	0	0	0	0	0	0	0	0
226	10	0	0	0	0	0	1	0	1	0	1
227	10	0	0	0	0	0	0	0	0	0	0
228	10	0	8	0	0	2	0	0	1	0	1
229	10	0	2	0	0	1	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0

TRAINING EQUIPMENT REQUIREMENTS — 12 LAUNCHES/YR — EXPERIENCE 80/20
40 HOURS/WK — RUN CODE 79634

DAY	RACKS	PSS	CONTROLS AND DISPLAYS A	B	C	D	E	AIR-LOCKS	VEIW-PORTS	CCTV	PERIPHERAL SIMULATORS
231	0	0	0	0	0	0	0	0	0	0	0
232	10	0	0	0	0	0	0	0	0	0	0
233	10	0	3	0	0	1	0	0	0	0	0
234	10	0	0	0	0	1	0	0	0	0	0
235	10	0	0	0	0	0	0	0	0	0	0
236	10	0	13	0	0	9	2	0	1	0	1
237	0	0	0	0	0	0	0	0	0	0	0
238	0	0	0	0	0	0	0	0	0	0	0
239	10	0	13	0	0	9	2	0	1	0	1
240	10	0	13	0	0	9	2	0	1	0	1
241	10	0	13	0	0	9	2	0	1	0	1
242	10	0	13	0	0	9	2	0	1	0	1
243	0	0	0	0	0	0	0	0	0	0	0
244	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0
246	0	0	0	0	0	0	0	0	0	0	0
247	0	0	0	0	0	0	0	0	0	0	0
248	0	0	0	0	0	0	0	0	0	0	0
249	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0
251	0	0	0	0	0	0	0	0	0	0	0
252	0	0	0	0	0	0	0	0	0	0	0
253	0	0	0	0	0	0	0	0	0	0	0
254	0	0	0	0	0	0	0	0	0	0	0
255	0	0	0	0	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	0	0	0	0
257	0	0	0	0	0	0	0	0	0	0	0
258	0	0	0	0	0	0	0	0	0	0	0
259	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0
261	0	0	0	0	0	0	0	0	0	0	0
262	0	0	0	0	0	0	0	0	0	0	0
263	0	0	0	0	0	0	0	0	0	0	0
264	0	0	0	0	0	0	0	0	0	0	0
265	0	0	0	0	0	0	0	0	0	0	0
266	0	0	0	0	0	0	0	0	0	0	0
267	16	0	0	0	2	0	2	0	0	1	1
268	16	0	0	0	2	0	2	0	0	1	1
269	16	0	0	0	2	0	2	0	0	1	1
270	16	0	0	0	0	0	0	0	0	0	0
271	16	0	0	0	0	0	0	0	0	0	0
272	0	0	0	0	0	0	0	0	0	0	0
273	0	0	0	0	0	0	0	0	0	0	0
274	16	0	0	0	0	0	2	1	1	1	1
275	16	0	0	0	0	0	2	1	1	1	1
276	16	0	0	0	0	0	2	1	1	1	1

TRAINING EQUIPMENT REQUIREMENTS 12 LAUNCHES/YR EXPERIENCE 80/20

40 HOURS/WK RUN CODE 79634

DAY	RACKS	PSS	CONTROLS AND DISPLAYS A	B	C	D	E	AIR-LOCKS	VEIW-PORTS	CCTV	PERIPHERAL SIMULATORS
277	16	0	0	0	0	0	0	0	0	0	0
278	16	0	0	0	0	0	0	0	0	0	0
279	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0
281	16	0	0	0	2	0	2	1	1	1	1
282	16	0	0	0	2	0	2	1	1	1	1
283	16	1	1	0	0	1	2	1	2	1	2
284	16	1	1	0	0	1	2	1	2	1	2
285	16	1	1	0	0	1	0	0	1	0	1
286	0	0	0	0	0	0	0	0	0	0	0
287	0	0	0	0	0	0	0	0	0	0	0
288	16	1	1	0	0	1	1	1	2	1	2
289	16	1	1	0	0	1	0	0	1	0	1
290	16	1	1	0	2	1	2	1	2	1	2
291	0	1	1	0	2	1	2	1	2	1	2
292	16	1	1	0	0	1	0	0	1	0	1
293	0	0	0	0	0	0	0	0	0	0	0
294	0	0	0	0	0	0	0	0	0	0	0
295	16	0	0	0	3	0	3	1	1	1	1
296	16	0	0	0	3	0	3	1	1	1	1
297	16	0	0	0	3	0	3	1	1	1	1
298	16	0	0	0	3	0	3	1	1	1	1
299	16	0	0	0	3	0	3	1	1	1	1
300	0	0	0	0	0	0	0	0	0	0	0
301	0	0	0	0	0	0	0	0	0	0	0
302	0	0	0	0	0	0	0	0	0	0	0
303	0	0	0	0	0	0	0	0	0	0	0
304	0	0	0	0	0	0	0	0	0	0	0
305	0	0	0	0	0	0	0	0	0	0	0
306	0	0	0	0	0	0	0	0	0	0	0
307	0	0	0	0	0	0	0	0	0	0	0
308	0	0	0	0	0	0	0	0	0	0	0
309	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0
311	0	0	0	0	0	0	0	0	0	0	0
312	0	0	0	0	0	0	0	0	0	0	0
313	0	0	0	0	0	0	0	0	0	0	0
314	0	0	0	0	0	0	0	0	0	0	0
315	0	0	0	0	0	0	0	0	0	0	0
316	0	0	0	0	0	0	0	0	0	0	0
317	0	0	0	0	0	0	0	0	0	0	0
318	0	0	0	0	0	0	0	0	0	0	0
319	0	0	0	0	0	0	0	0	0	0	0
320	16	0	1	2	3	2	2	0	0	1	0
321	0	0	0	0	0	0	0	0	0	0	0
322	0	0	0	0	0	0	0	0	0	0	0

TRAINING EQUIPMENT REQUIREMENTS   12 LAUNCHES/YR   EXPERIENCE 80/20
40 HOURS/WK   RUN CODE 79634

			CONTROLS AND DISPLAYS					AIR-	VIEW-		PERIPHERAL
DAY	RACKS	PSS	A	B	C	D	E	LOCKS	PORTS	CCTV	SIMULATORS
323	16	0	1	2	3	2	2	0	0	1	0
324	16	0	1	2	3	2	2	0	0	1	0
325	16	0	1	2	3	2	2	0	0	1	0
326	16	0	1	2	3	2	2	0	0	1	0
327	16	0	1	2	3	2	2	0	0	1	0
328	0	0	0	0	0	0	0	0	0	0	0
329	0	0	0	0	0	0	0	0	0	0	0
330	16	0	0	0	0	0	0	0	0	0	0
331	16	0	0	0	0	0	0	0	0	0	0
332	16	0	0	0	1	3	1	0	0	0	0
333	16	0	0	0	1	3	1	0	0	0	0
334	16	0	0	0	1	3	1	0	0	0	0
335	0	0	0	0	0	0	0	0	0	0	0
336	0	0	0	0	0	0	0	0	0	0	0
337	16	0	0	0	1	3	1	0	0	0	0
338	16	0	0	0	1	3	1	0	0	0	0
339	16	0	0	0	0	0	0	0	0	0	0
340	16	0	1	2	4	5	3	0	0	1	0
341	16	0	1	2	4	5	3	0	0	1	0
342	0	0	0	0	0	0	0	0	0	0	0
343	0	0	0	0	0	0	0	0	0	0	0
344	0	0	0	0	0	0	0	0	0	0	0
345	0	0	0	0	0	0	0	0	0	0	0
346	0	0	0	0	0	0	0	0	0	0	0
347	0	0	0	0	0	0	0	0	0	0	0
348	0	0	0	0	0	0	0	0	0	0	0
349	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0
351	0	0	0	0	0	0	0	0	0	0	0
352	0	0	0	0	0	0	0	0	0	0	0
353	0	0	0	0	0	0	0	0	0	0	0
354	0	0	0	0	0	0	0	0	0	0	0
355	0	0	0	0	0	0	0	0	0	0	0
356	0	0	0	0	0	0	0	0	0	0	0
357	0	0	0	0	0	0	0	0	0	0	0
358	0	0	0	0	0	0	0	0	0	0	0
359	0	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0
361	8	0	0	0	0	0	0	0	0	0	0
362	8	0	0	0	0	1	0	0	1	1	1
363	0	0	0	0	0	0	0	0	0	0	0
364	0	0	0	0	0	0	0	0	0	0	0

APPROVAL

DEVELOPMENT AND ANALYSIS OF A MODULAR APPROACH TO PAYLOAD SPECIALIST TRAINING

By Harry Watters and Jackie Steadman

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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